



US009234697B2

(12) **United States Patent**  
**Youn et al.**

(10) **Patent No.:** **US 9,234,697 B2**  
(45) **Date of Patent:** **Jan. 12, 2016**

(54) **REFRIGERATOR**

(75) Inventors: **Deok-Hyun Youn**, Gimhae-si (KR);  
**Ju-Hyun Kim**, Jinhae-si (KR); **Sang-Ho Oh**, Daegu (KR); **Cheol-Hwan Kim**,  
Changwon-si (KR); **Hoon-Bong Lee**,  
Changwon-si (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 1195 days.

(21) Appl. No.: **13/139,966**

(22) PCT Filed: **Dec. 10, 2009**

(86) PCT No.: **PCT/KR2009/007398**

§ 371 (c)(1),  
(2), (4) Date: **Aug. 31, 2011**

(87) PCT Pub. No.: **WO2010/071326**

PCT Pub. Date: **Jun. 24, 2010**

(65) **Prior Publication Data**

US 2011/0302940 A1 Dec. 15, 2011

(30) **Foreign Application Priority Data**

Dec. 16, 2008	(KR)	10-2008-0128098
Jan. 8, 2009	(KR)	10-2009-0001664
Jan. 8, 2009	(KR)	10-2009-0001669
Nov. 10, 2009	(KR)	10-2009-0108313

(51) **Int. Cl.**  
**F25D 17/00** (2006.01)  
**F25D 29/00** (2006.01)  
**F25D 17/06** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **F25D 29/00** (2013.01); **F25D 17/062**  
(2013.01); **F25D 2317/061** (2013.01); **F25D**  
**2600/04** (2013.01)

(58) **Field of Classification Search**

CPC ... Y10S 165/918; Y10S 165/919; A23L 3/36;  
A47B 2031/026; A23G 9/045; F25D 29/00;  
F25D 17/062; F25D 2317/061; F25D 2600/04  
USPC ..... 165/205, 202, 919, 918, 203, 42, 43,  
165/48.1; 62/129

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,602,756 A \* 2/1997 Atwood et al. .... 700/269  
7,086,459 B2 \* 8/2006 Beitelmal et al. .... 165/205

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1 813 894 A2 8/2007  
EP 1 980 808 A2 10/2008

(Continued)

*Primary Examiner* — Ljiljana Ciric

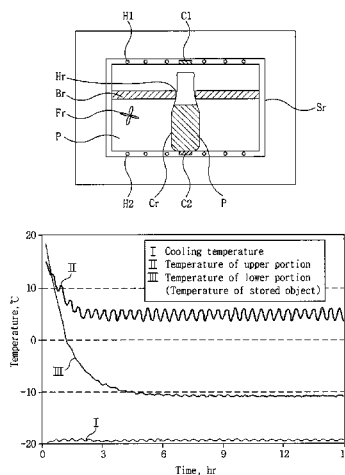
*Assistant Examiner* — Alexis Cox

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch &  
Birch, LLP

(57) **ABSTRACT**

A refrigerator includes a control apparatus and a storing space composed of an upper space and a lower space between which the air or heat exchange is limited. The storing space has a liquid in a supercooled state. A determination unit calculates an accumulated time during which the temperature of the storing space is maintained in a supercooling temperature range below the maximum ice crystal formation zone of the stored liquid after the sensed temperature enters the supercooling temperature range, compares the accumulated time with a supercooled-state determination time and determines that the stored liquid is in the supercooled state if the accumulated time is equal to or greater than the supercooled-state determination time.

**5 Claims, 14 Drawing Sheets**



(56)

**References Cited**

U.S. PATENT DOCUMENTS

8,464,544	B2 *	6/2013	Shin et al. ....	62/157
8,572,990	B2 *	11/2013	Chung et al. ....	62/129
2002/0112488	A1 *	8/2002	Daum et al. ....	62/125
2003/0085032	A1 *	5/2003	Shimoda ....	165/205
2004/0028786	A1 *	2/2004	Tani et al. ....	426/524
2008/0245081	A1 *	10/2008	Shin et al. ....	62/80
2009/0064689	A1 *	3/2009	Kim et al. ....	62/56
2009/0258337	A1 *	10/2009	Yagi ....	435/1.1
2010/0083687	A1 *	4/2010	Handa et al. ....	62/419
2010/0089094	A1 *	4/2010	Kondou et al. ....	62/498
2010/0199692	A1 *	8/2010	Kim et al. ....	62/62

2010/0319368	A1 *	12/2010	Kim et al. ....	62/75
2011/0219800	A1 *	9/2011	Lee ....	62/186
2011/0219805	A1 *	9/2011	Youn et al. ....	62/331
2011/0277487	A1 *	11/2011	Oh ....	62/56
2011/0302952	A1 *	12/2011	Chung et al. ....	62/408

FOREIGN PATENT DOCUMENTS

JP	2001-4260	A	1/2001
JP	2008-267646	A	11/2008
JP	2008-267789	A	11/2008
KR	10-0850062	B1	8/2008
WO	WO 2008/150108	A2	12/2008

\* cited by examiner

Figure 1

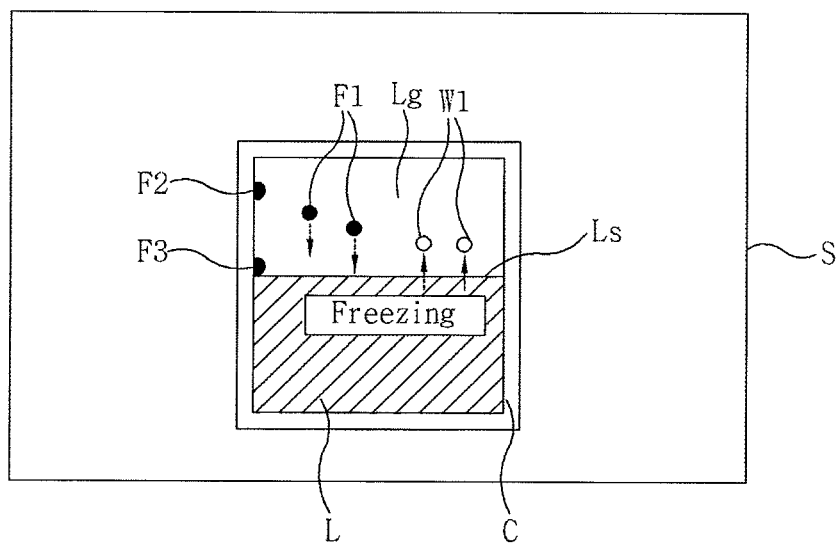


Figure 2

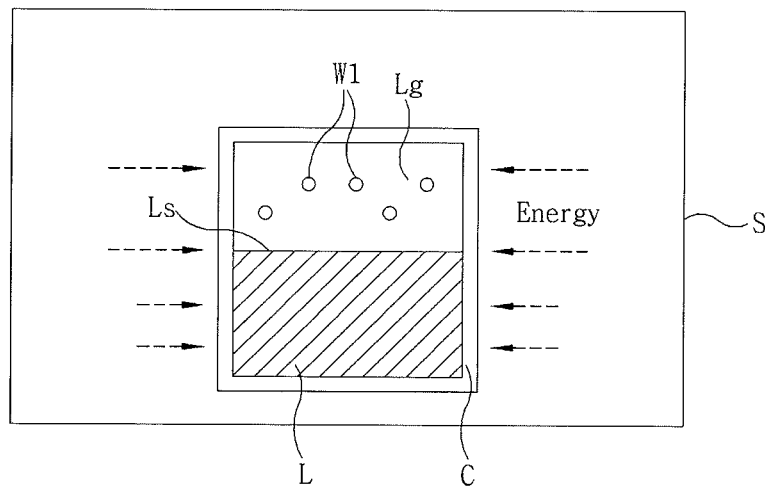


Figure 3

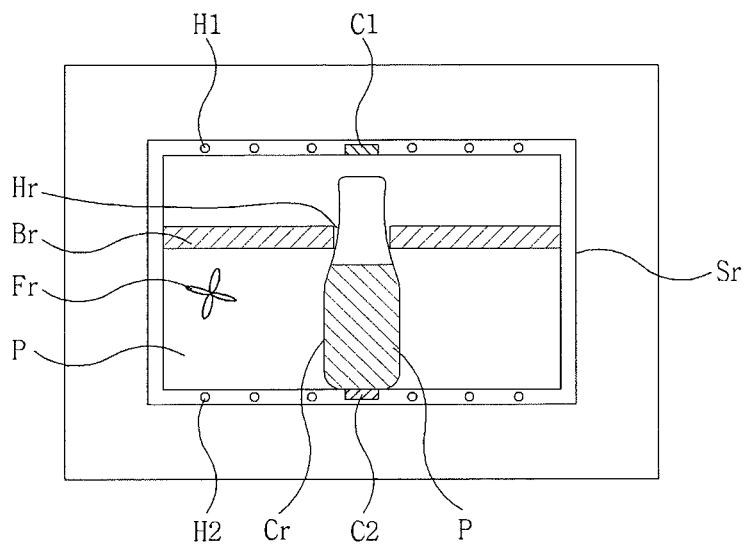


Figure 4

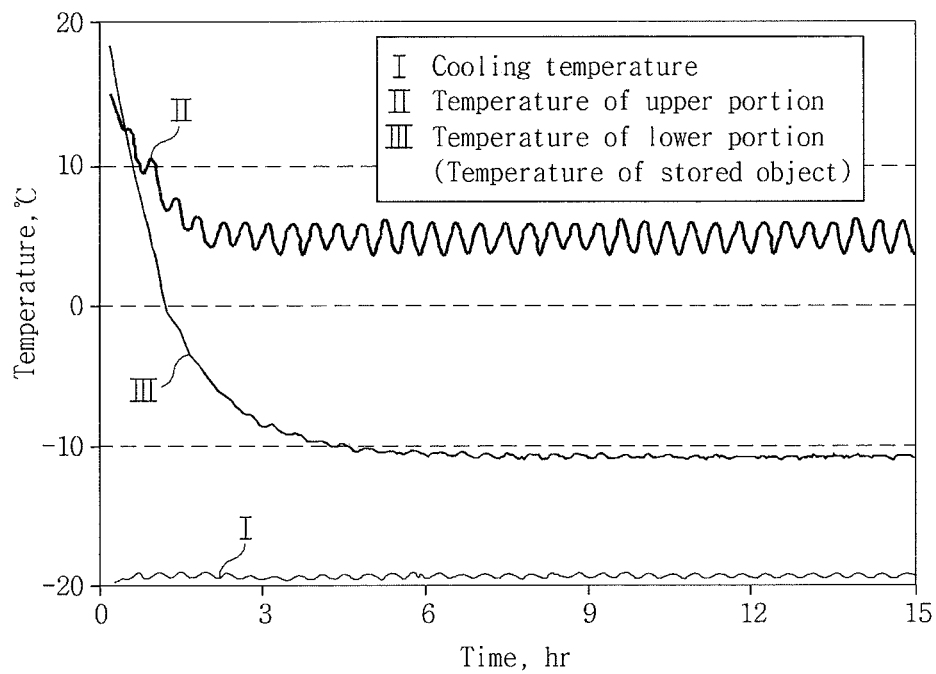
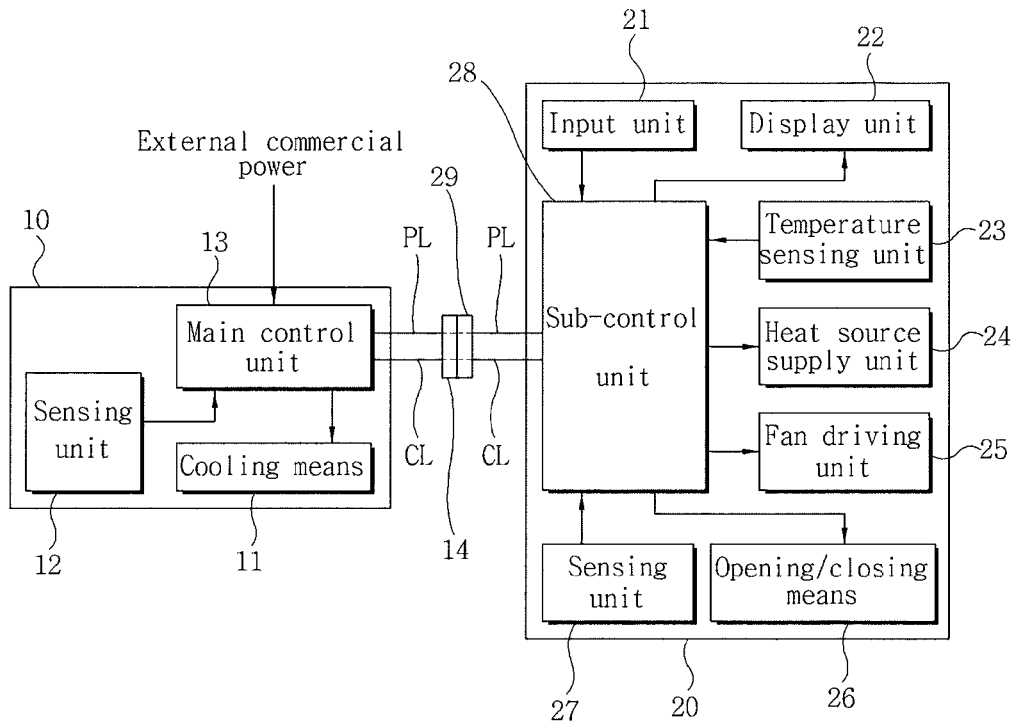


Figure 5



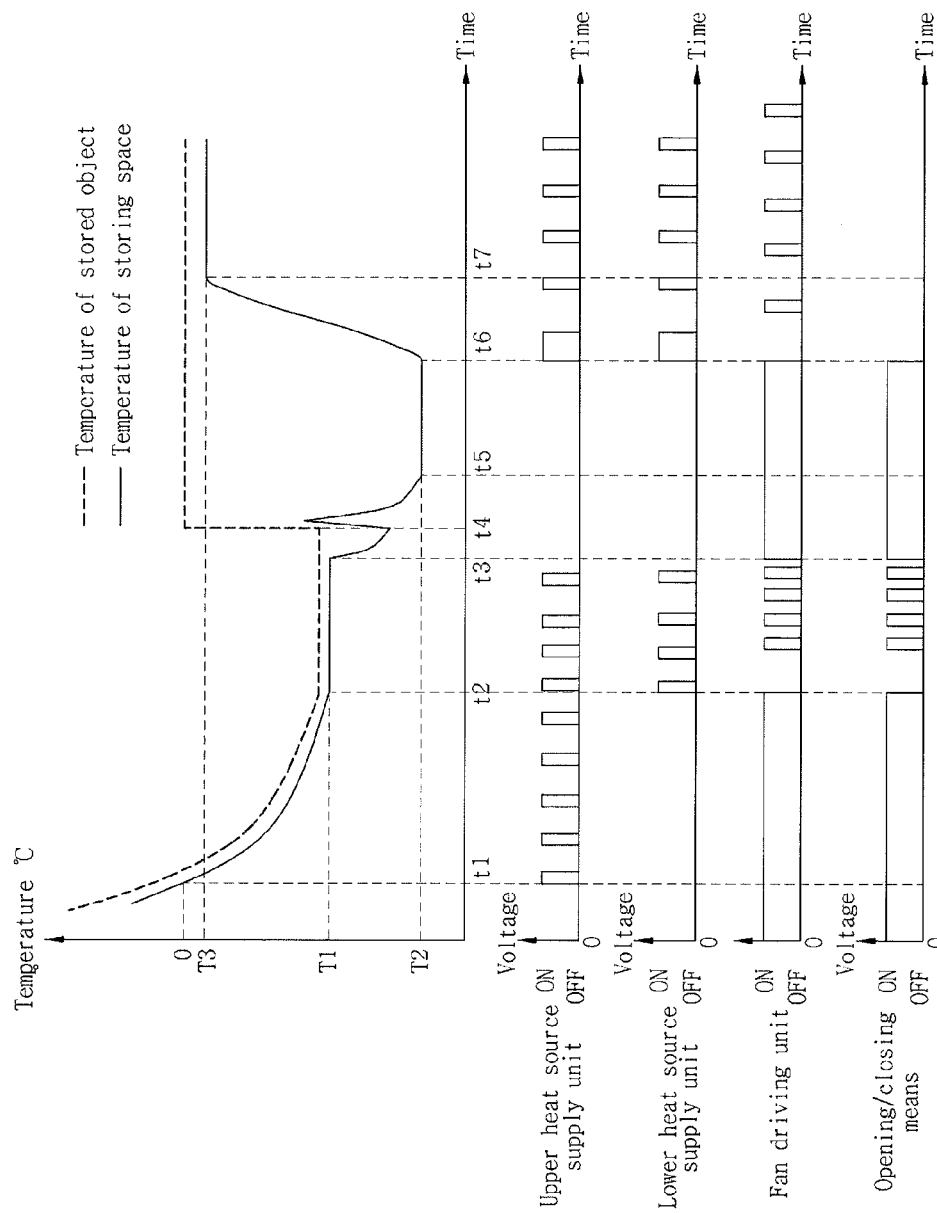


Figure 6

Figure 7

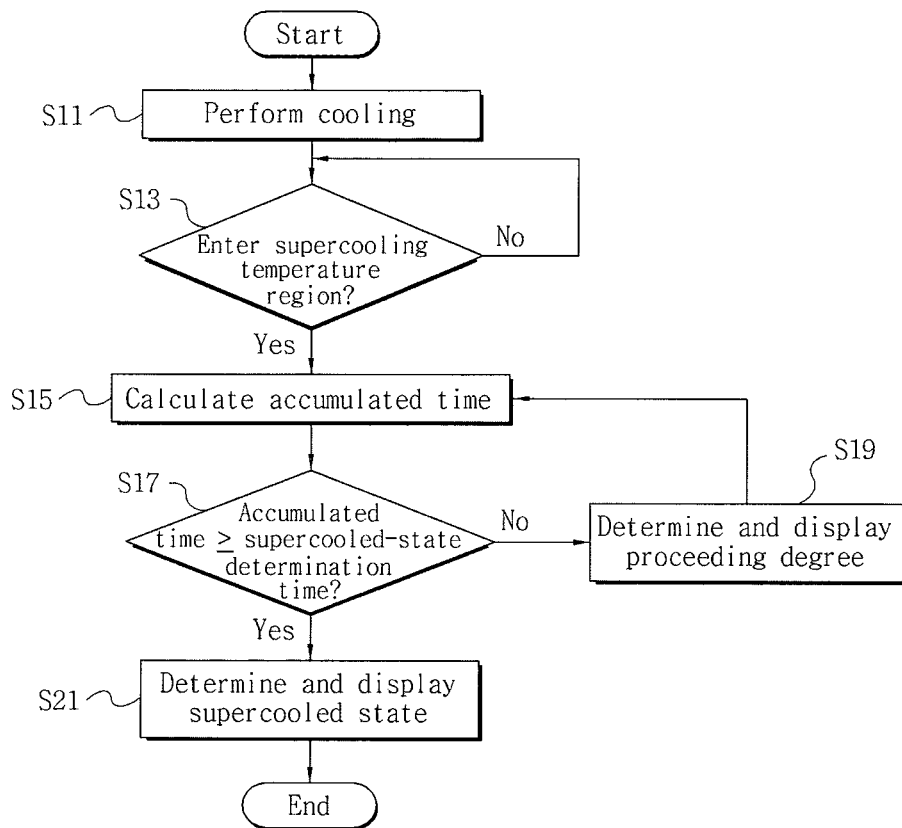


Figure 8

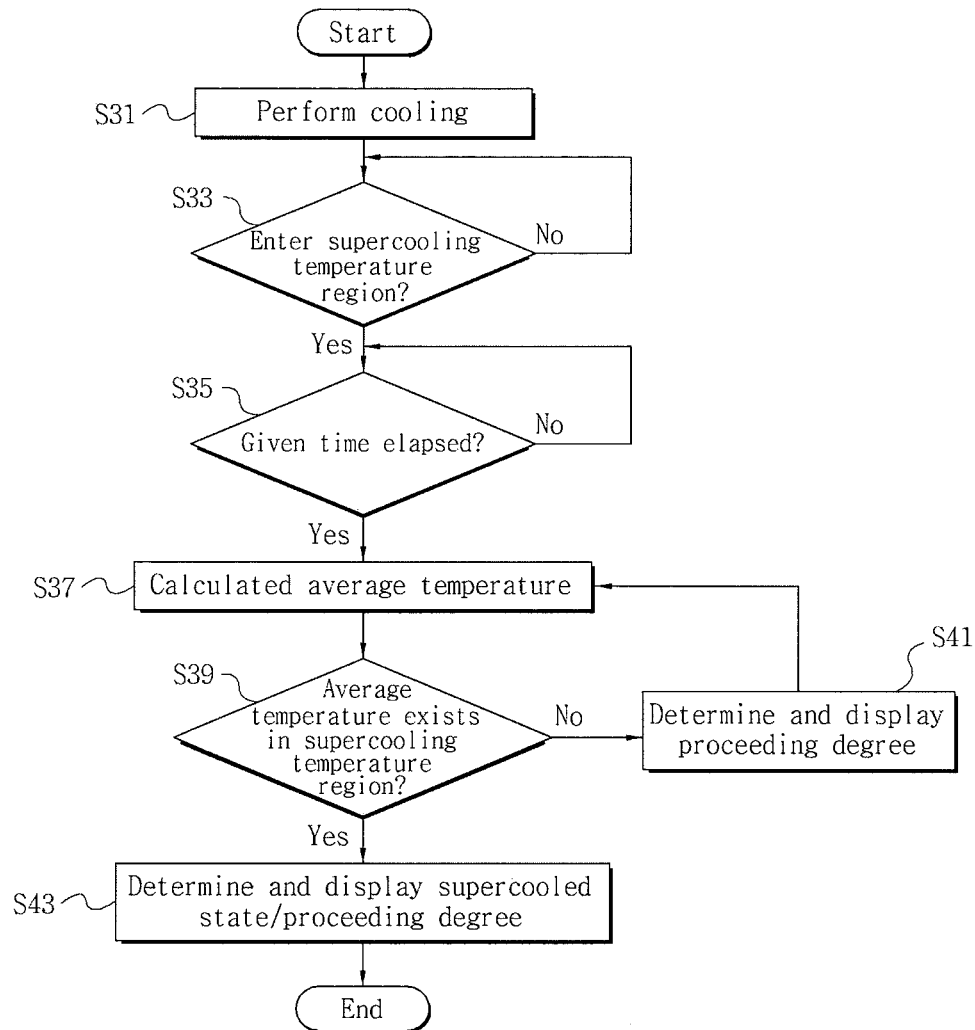


Figure 9

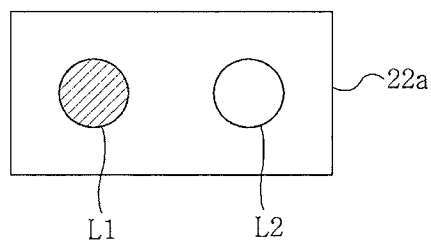




Figure 10

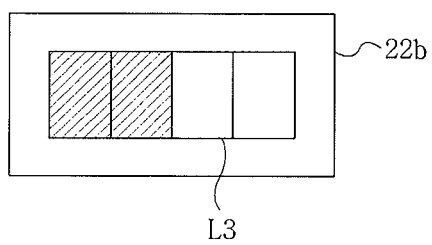


Figure 11

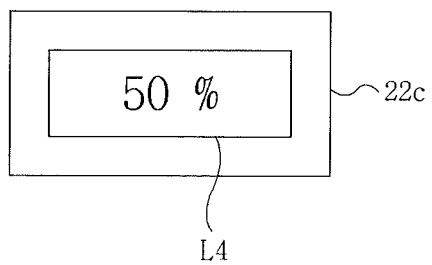


Figure 12

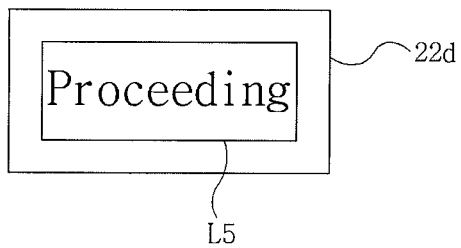


Figure 13

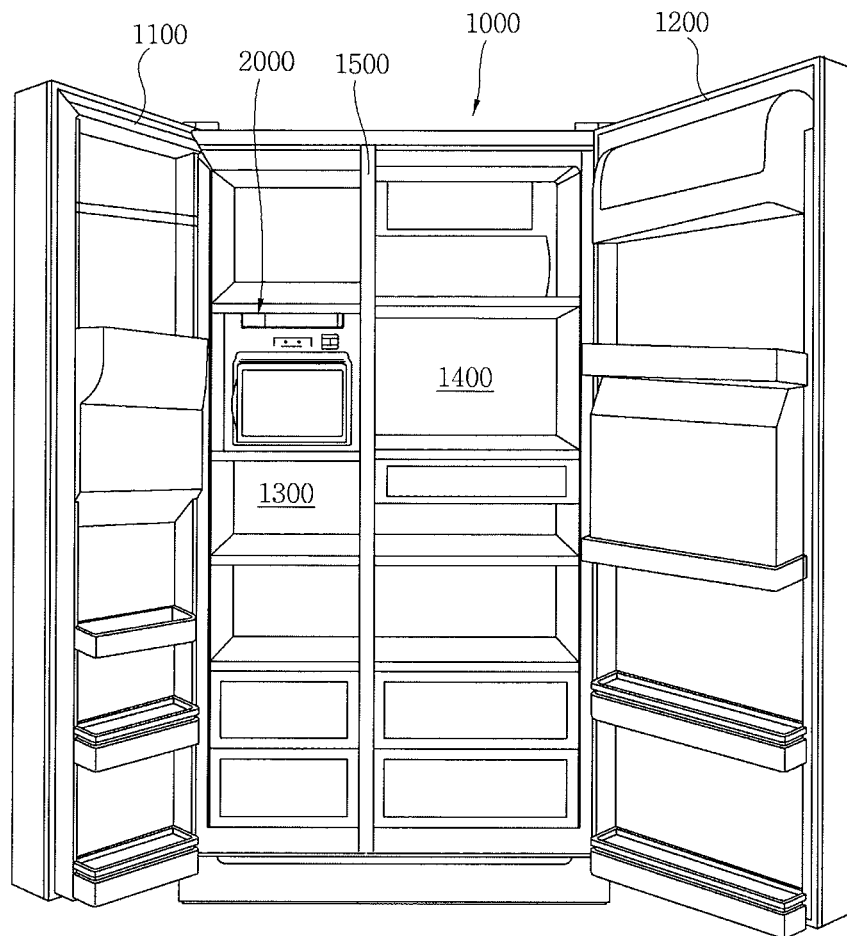


Figure 14

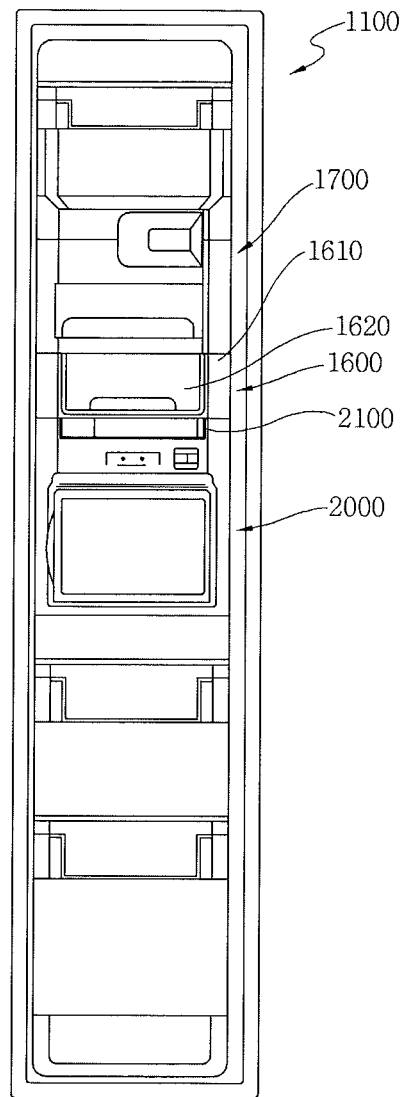




Figure 16

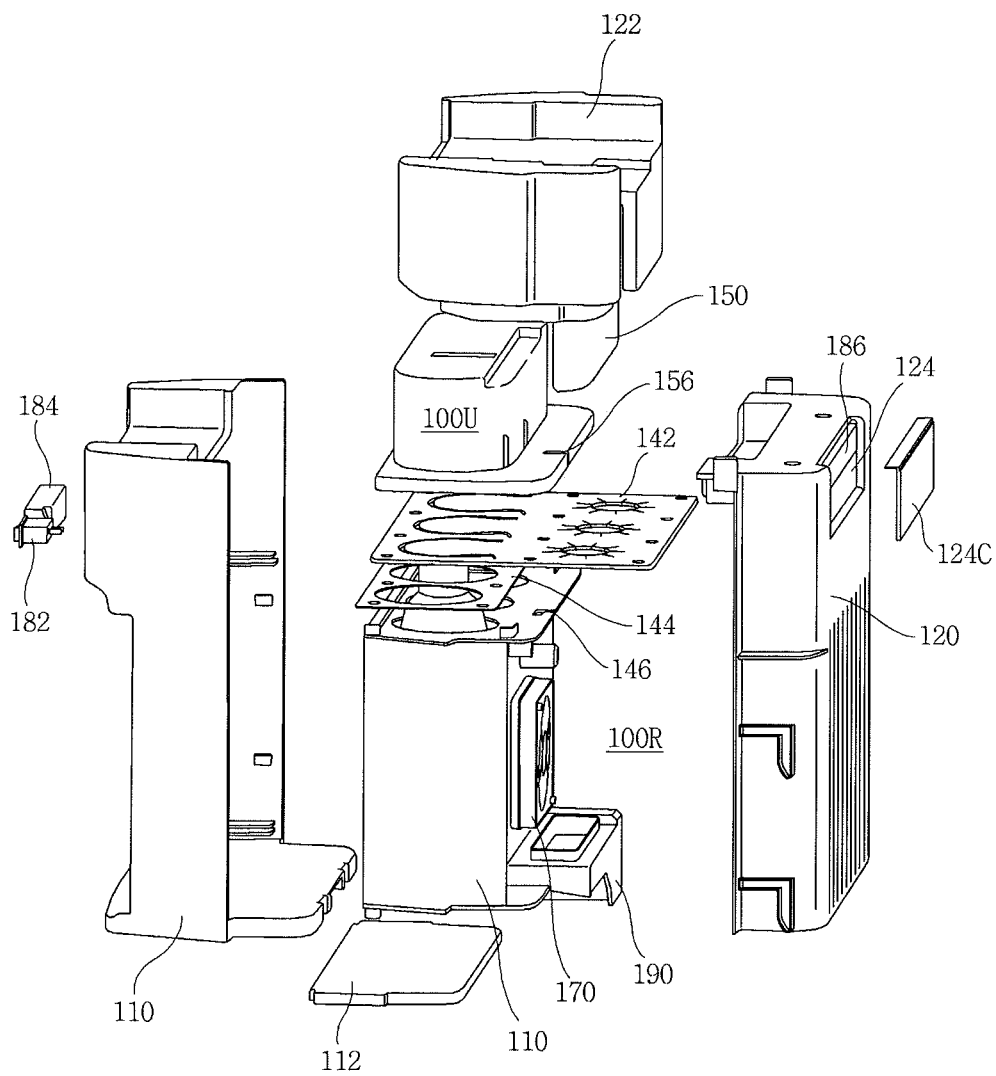


Figure 17

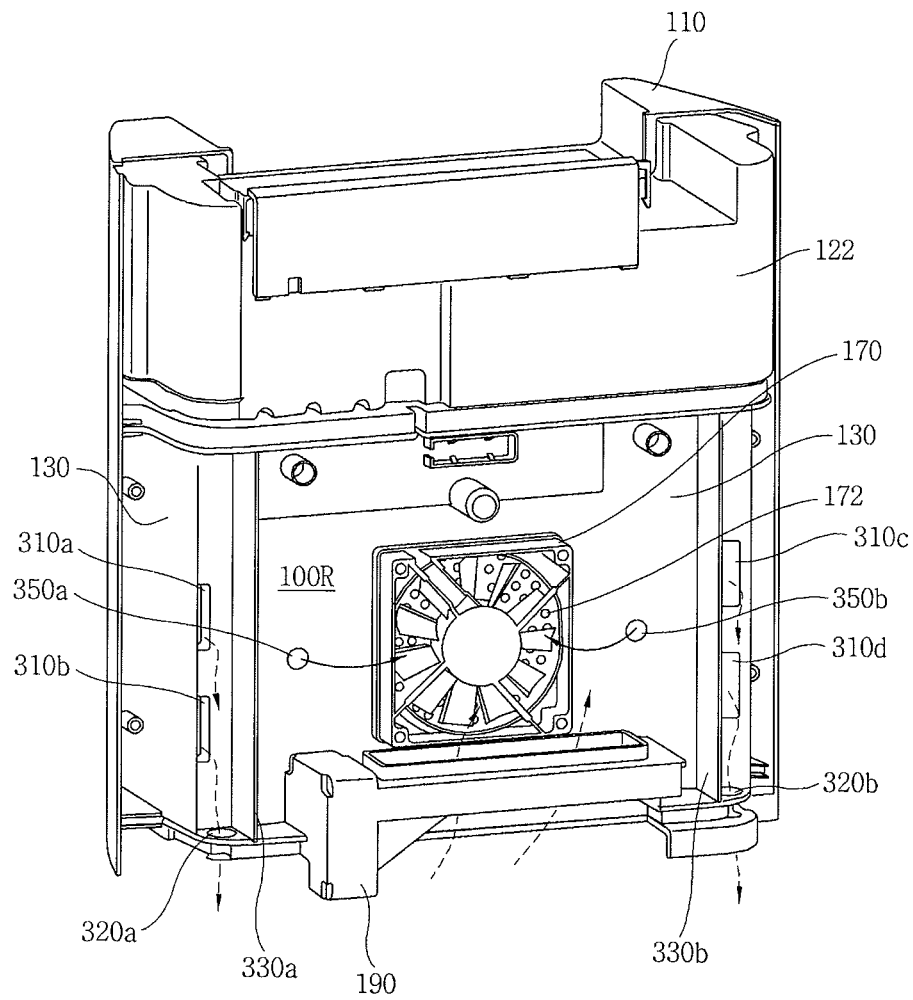


Figure 18

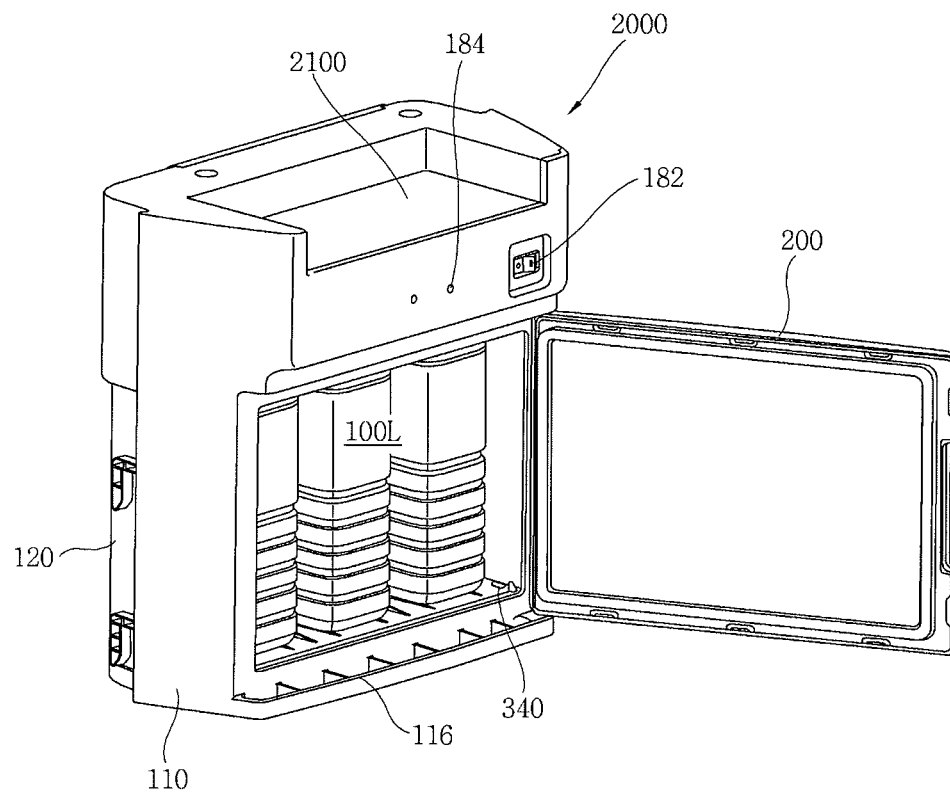
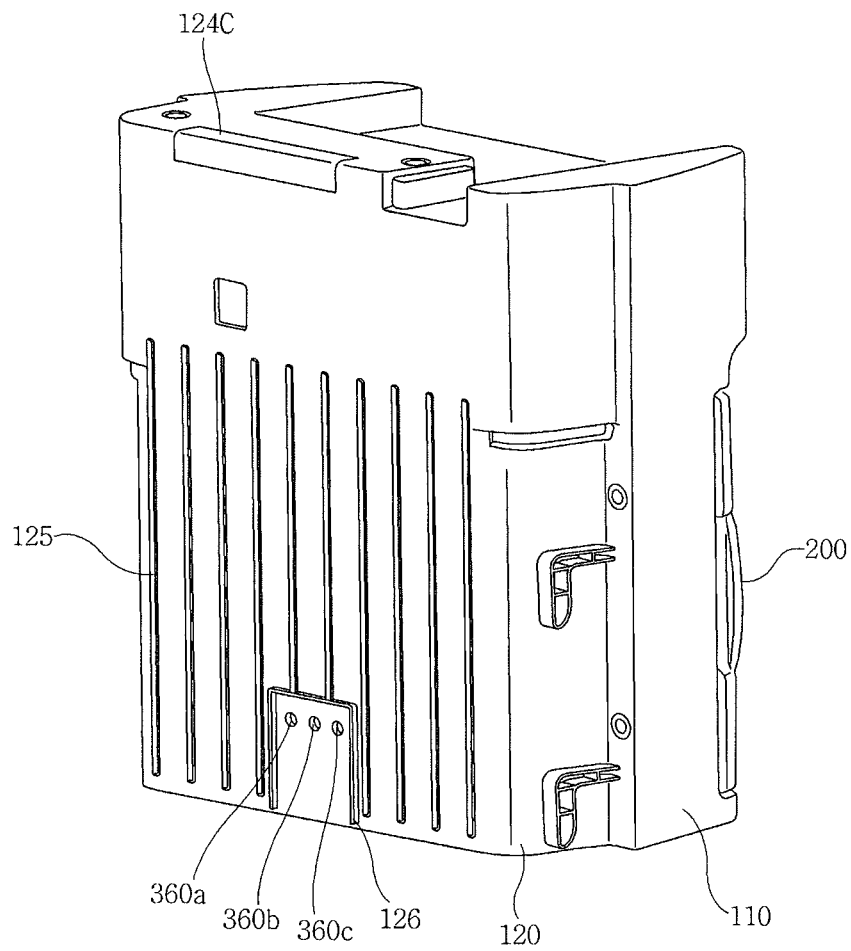


Figure 19





1

**REFRIGERATOR****TECHNICAL FIELD**

The present invention relates to a refrigerator, and, more particularly, to a refrigerator which displays a supercooled state or the proceeding degree of the supercooled state.

**BACKGROUND ART**

Supercooling means the phenomenon that a molten object or a solid is not changed although it is cooled to a temperature below the phase transition temperature in an equilibrium state. A material has a stable state at every temperature. If the temperature is slowly changed, the constituent elements of the material can follow the temperature changes, maintaining the stable state at each temperature. However, if the temperature is suddenly changed, since the constituent elements cannot be changed into the stable state at each temperature, the constituent elements maintain a stable state at an initial temperature, or some of the constituent elements fail to be changed into a state at a final temperature.

For example, when water is slowly cooled, it is not temporarily frozen at a temperature below 0° C. However, when water enters a supercooled state, it has a kind of quasi-stable state. As this unstable equilibrium state is easily broken even by slight stimulation, water tends to move into a more stable state. That is, if a small piece of the material is put into the supercooled liquid, or if the liquid is suddenly shaken, the liquid starts to be frozen at once such that its temperature reaches the freezing point, and maintains a stable equilibrium state at the temperature.

In general, an electrostatic atmosphere is made in a refrigerator, and meat and fish are thawed in the refrigerator at a minus temperature. In addition to the meat and fish, fruit is kept fresh in the refrigerator.

This technology uses a supercooling phenomenon. The supercooling phenomenon indicates the phenomenon that a molten object or a solid is not changed although it is cooled to a temperature below the phase transition temperature in an equilibrium state. In the prior art, an electric field or magnetic field is applied to the stored object to be cooled such that the stored object enters a supercooled state. Accordingly, a complicated apparatus for producing the electric field or magnetic field should be provided to store the stored object in the supercooled state, and the power consumption is increased during the production of the electric field or magnetic field. Additionally, the apparatus for producing the electric field or magnetic field should further include a safety device (e.g., an electric field or magnetic field shielding structure, an interception device, etc.) for protecting the user from high power, when producing or intercepting the electric field or magnetic field.

Japanese Patent Publication No. 2001-4260 describes a supercooling control refrigerator which includes a temperature detection means and a control means controlling the temperature at a given set temperature in an openable/closable insulation unit and which keeps the goods cold at a temperature below the freezing point during the supercooling operation. However, since the refrigerator controls the rotation number of a cool air circulation fan to adjust the temperature in the insulation unit, if the temperature in the unit is reduced to a temperature below the set temperature, there is no means for raising the temperature to the set temperature within a short time. Korean Registered Patent No. 10-850062 describes a refrigerator having a space for storing food and a storing room for cooling the space, the refrigerator including

2

a cool air flowing space directly cooling the food storing space and an insulation layer insulating the cool air flowing space from the space, and storing the food in a supercooled state.

Japanese Patent Publication No. 2008-267646 describes a refrigerator with a supercooling room which includes a freezing chamber with a temperature control means therein to continuously adjust the temperature between 0° C. and a temperature of a freezing temperature zone by stages, the supercooling room disposed in the freezing chamber and receiving the cool air from the freezing chamber, and a control apparatus controlling the freezing chamber so that the food stored in the supercooling room can be maintained in a supercooled state at a temperature below the freezing point without being frozen.

The aforementioned prior arts describe only the construction for storing the stored object in the supercooled state.

**DISCLOSURE****Technical Problem**

An object of the present invention is to provide a refrigerator which can display a supercooled state of a stored object, while it is maintained in the supercooled state, or the proceeding degree of the supercooled state.

Another object of the present invention is to provide a refrigerator which can accurately determine a state of a stored object.

**Technical Solution**

According to an aspect of the present invention, there is provided a refrigerator including a control apparatus which is formed in a storing space in which the cooling is performed, has a storing space composed of an upper space and a lower space between which the air or heat exchange is limited, stores a stored object in the storing space in a supercooled state, and controls the temperature of the upper space and the lower space, respectively, the refrigerator, comprising: a determination means determining the supercooled state of the stored object or the proceeding degree of the supercooled state; and a display means visually or aurally displaying the supercooled state or the proceeding degree of the supercooled state determined by the determination means.

In addition, preferably, the determination means includes a temperature sensing unit sensing the temperature of the storing space, and a determination unit determining the supercooled state or the proceeding degree of the supercooled state based on the time during which the sensed temperature is maintained in a supercooling temperature region.

Moreover, preferably, after the sensed temperature enters the supercooling temperature range, the determination unit compares the accumulated time during which the temperature of the storing space is included in the supercooling temperature region with a supercooled-state determination time and determines the supercooled state of the stored object or the proceeding degree of the supercooled state.

Further, preferably, the determination means includes a temperature sensing unit sensing the temperature of the storing space, and a determination unit comparing the average temperature of the storing space with a supercooling temperature region and determining the supercooled state of the stored object or the proceeding degree of the supercooled state.

Furthermore, preferably, the average temperature of the storing space is the average temperature over a given time.

3

Still furthermore, preferably, the average temperature of the storing space is calculated after the temperature of the storing space enters the supercooling temperature region. Still furthermore, preferably, the display means displays the supercooled state or the cooled state.

Still furthermore, preferably, the display means displays the proceeding degree of the supercooled state by multiple stages.

Still furthermore, preferably, the determination means enables the display means to display stages corresponding to a ratio or proximity degree of the accumulated time to the supercooled-state determination time.

Still furthermore, preferably, the determination means enables the display means to display stages corresponding to a ratio or proximity degree of the average temperature to the supercooling temperature region.

Still furthermore, preferably, the determination means performs the operation after power is applied to the control apparatus or after a supercooling operation command is acquired from an input means connected to the control apparatus.

#### Advantageous Effects

An embodiment of the present invention can accurately determine and display a supercooled state of a stored object, while it is maintained in the supercooled state, or the proceeding degree of the supercooled state using the average temperature or the accumulated time.

Another embodiment of the present invention can determine a supercooled state based on the average temperature over a given time, and thus accurately determine a state of a stored object, although a temperature change caused in a storing unit by the opening of a door affects a control apparatus.

A further embodiment of the present invention can accurately determine a state of a stored object using the accumulated time, i.e., the time during which an actual supercooling operation is performed to maintain the stored object in a supercooling temperature region.

#### DESCRIPTION OF DRAWINGS

FIG. 1 is a view showing a process of forming ice crystal nucleuses in a liquid during the cooling.

FIG. 2 is a view showing a process of preventing the ice crystal nucleus formation, which is applied to a temperature control apparatus (or a non-freezing apparatus) of a storage room according to the present invention.

FIG. 3 is a schematic configuration view of the temperature control apparatus (or the non-freezing apparatus) of the storage room according to the present invention.

FIG. 4 is a graph showing a supercooled state of water using the temperature control apparatus (or the non-freezing apparatus) of the storage room of FIG. 3.

FIG. 5 is a schematic block diagram of a refrigerator employing a temperature control apparatus (or a non-freezing apparatus) of a storage room according to the present invention.

FIG. 6 is a temperature graph and an operation state view of processes performed by the non-freezing apparatus according to the present invention.

FIG. 7 is a flowchart showing a first determination and display method in the refrigerator according to the present invention.

4

FIG. 8 is a flowchart showing a second determination and display method in the refrigerator according to the present invention.

FIGS. 9 to 12 are views of examples of the display method. FIG. 13 is a view of a refrigerator according to a first embodiment of the present invention.

FIG. 14 is a view of a refrigerator according to a second embodiment of the present invention.

FIGS. 15 and 16 are exploded perspective views of a non-freezing apparatus according to an embodiment of the present invention.

FIG. 17 is a view of a rear space of the non-freezing apparatus according to the embodiment of the present invention.

FIG. 18 is a perspective view of the non-freezing apparatus according to the embodiment of the present invention.

FIG. 19 is a view of the rear of the non-freezing apparatus according to the embodiment of the present invention.

#### MODE FOR INVENTION

Hereinafter, the present invention will be described in detail with reference to the exemplary embodiments and the accompanying drawings.

FIG. 1 is a view showing a process of forming ice crystal nucleuses in a liquid during the cooling. As illustrated in FIG. 1, a container C containing a liquid L (or a stored object) is cooled in a storing unit S with a cooling space therein.

For example, it is assumed that a cooling temperature of the cooling space is lowered from a normal temperature to a temperature below 0° C. (the phase transition temperature of water) or a temperature below the phase transition temperature of the liquid L. While the cooling is carried out, it is intended to maintain a supercooled state of the water or the liquid L (or the stored object) at a temperature below the maximum ice crystal formation zone (−1° C. to −7° C.) of the water in which the formation of ice crystals is maximized, or at a cooling temperature below the maximum ice crystal formation zone of the liquid L.

The liquid L is evaporated during the cooling such that vapor W1 is introduced into a gas Lg (or a space) in the container C. In a case where the container C is closed, the gas Lg may be supersaturated due to the evaporated vapor W1.

When the cooling temperature reaches or exceeds a temperature of the maximum ice crystal formation zone of the liquid L, the vapor W1 forms ice crystal nucleuses F1 in the gas Lg or ice crystal nucleuses F2 on an inner wall of the container C. Alternatively, the condensation occurs in a contact portion of the surface Ls of the liquid L and the inner wall of the container C (almost the same as the cooling temperature of the cooling space) such that the condensed liquid L may form ice crystal nucleuses F3 which are ice crystals.

For example, when the ice crystal nucleuses F1 in the gas Lg are lowered and infiltrated into the liquid L through the surface Ls of the liquid L, the liquid L is released from the supercooled state and caused to be frozen. That is, the supercooling of the liquid L is released.

Alternatively, as the ice crystal nucleuses F3 are brought into contact with the surface Ls of the liquid L, the liquid L is released from the supercooled state and caused to be frozen.

As described above, according to the process of forming the ice crystal nucleuses F1 to F3, when the liquid L is stored at a temperature below its maximum ice crystal formation zone, the liquid L is released from the supercooled state due to the freezing of the vapor evaporated from the liquid L and

5

existing on the surface Ls of the liquid L and the freezing of the vapor on the inner wall of the container C adjacent to the surface Ls of the liquid L.

FIG. 2 is a view showing a process of preventing the ice crystal nucleus formation, which is applied to a temperature control apparatus (or a non-freezing apparatus) of a storage room according to the present invention.

In FIG. 2, to prevent the freezing of the vapor W1 in the gas Lg, i.e., to continuously maintain the vapor W1 state, the energy is applied to at least the gas Lg or the surface Ls of the liquid L so that the temperature of the gas Lg or the surface Ls of the liquid L can be higher than a temperature of the maximum ice crystal formation zone of the liquid L, more preferably, the phase transition temperature of the liquid L. In addition, to prevent the freezing although the surface Ls of the liquid L is brought into contact with the inner wall of the container C, the temperature of the surface Ls of the liquid L is maintained higher than a temperature of the maximum ice crystal formation zone of the liquid L, more preferably, the phase transition temperature of the liquid L. Accordingly, the liquid L in the container C maintains the supercooled state at a temperature below its phase transition temperature or a temperature below its maximum ice crystal formation zone.

Moreover, when the cooling temperature of the storing unit S is a considerably low temperature, e.g.,  $-20^{\circ}\text{C}$ ., although the energy is applied to an upper portion of the container C, the liquid L which is the stored object may not be able to maintain the supercooled state. There is a need that the energy should be applied to a lower portion of the container C to some extent. When the energy applied to the upper portion of the container C is relatively larger than the energy applied to the lower portion of the container C, the temperature of the upper portion of the container C can be maintained higher than the phase transition temperature or a temperature of the maximum ice crystal formation zone. Further, the temperature of the liquid L in the supercooled state can be adjusted by the energy applied to the lower portion of the container C and the energy applied to the upper portion of the container C.

The liquid L has been described as an example with reference to FIGS. 1 and 2. In the case of a stored object containing a liquid, when the liquid in the stored object is continuously supercooled, the stored object can be kept fresh for an extended period of time. The stored object can be maintained in a supercooled state at a temperature below the phase transition temperature via the above process. Here, the stored object may include meat, vegetable, fruit and other food as well as the liquid.

Furthermore, the energy adopted in the present invention may be thermal energy, electric or magnetic energy, ultrasonic energy, light energy, and so on.

FIG. 3 is a schematic configuration view of the temperature control apparatus (or the non-freezing apparatus) of the storage room according to the present invention.

The temperature control apparatus of FIG. 3 includes a case Sr mounted in the storing unit S in which the cooling is performed, the case being a storage room with a storing space therein, a heat generation coil H1 mounted on the inside of a top surface of the case Sr and generating heat, a temperature sensor C1 sensing a temperature of an upper portion of the storing space, a heat generation coil H2 mounted on the inside of a bottom surface of the case Sr and generating heat, and a temperature sensor C2 sensing a temperature of the lower portion of the storing space or a temperature of a stored object P.

The temperature control apparatus is installed in the storing unit S such that the cooling is performed therein. The temperature sensors C1 and C2 sense the temperature and the

6

heat generation coils H1 and H2 are turned on to supply heat from the upper and lower portions of the storing space to the storing space. The heat supply quantity is adjusted to control the temperature of the upper portion of the storing space (or the air on the stored object P) to be higher than a temperature of the maximum ice crystal formation zone, more preferably, the phase transition temperature.

Particularly, a boundary film Br is formed in the case Sr to separate upper and lower portions of the storing space and prevent the heat exchange between the upper and lower portions thereof. The boundary film Br includes a hole Hr through which a top end portion of a container Cr containing a liquid P is located in the upper portion of the storing space. The portion of the boundary film Br around the hole Hr is made of an elastic material to minimize the air flow, particularly, the heat flow between the upper and lower portions of the storing space. The upper portion of the container Cr passes through the hole Hr of the boundary film Br and is located in the upper portion of the storing space, and the lower portion of the container Cr is located in the lower portion of the storing space. The boundary film Br makes it easy to maintain the upper and lower portions of the storing space or the upper and lower portions of the container Cr at a desired temperature. The temperature sensor C2 is disposed on a bottom surface of the container Cr to accurately sense the temperature of the container Cr or the liquid which is the stored object P.

In addition, a fan element Fr is provided in the lower storing space of the case Sr to circulate the air and heat in the lower portion by a forcible convection. Accordingly, the heat supplied by the heat generation coil H2 can be evenly transferred to the lower storing space and the stored object.

The positions of the heat generation coils H1 and H2 in FIG. 3 are appropriately determined to supply the heat (or energy) to the stored object P and the storing space. The heat generation coils H1 and H2 may be inserted into side surfaces of the case Sr.

FIG. 4 is a graph showing a water temperature of the temperature control apparatus (or the non-freezing apparatus) of FIG. 3. The graph of FIG. 4 is a temperature graph when the liquid L is water and the principle of FIGS. 2 and 3 is applied thereto. As illustrated in FIG. 4, line I represents a curve of the cooling temperature of the cooling space, line II represents a curve of the temperature of the gas Lg (air) on the surface of the water in the container C or the case Sr (or the temperature of the upper portion of the container C or the case Sr), and line III represents a curve of the temperature of the lower portion of the container C, the case Sr or the container Cr. A temperature of an outer surface of the container C, the case Sr or the container Fr is substantially identical to the temperature of the water or liquid in the container C, the case Sr or the container Cr.

As shown, in a case where the cooling temperature is maintained at about  $-19^{\circ}\text{C}$ . to  $-20^{\circ}\text{C}$ . (see line I), when the temperature of the gas Lg on the surface of the water in the container C is maintained at about  $4^{\circ}\text{C}$ . to  $6^{\circ}\text{C}$ . which is higher than a temperature of the maximum ice crystal formation zone of the water, the temperature of the water in the container C is maintained at about  $-11^{\circ}\text{C}$ . which is lower than a temperature of the maximum ice crystal formation zone of the water, but the water is stably maintained in a supercooled state which is a liquid state for an extended period of time. Here, the heat generation coils H1 and H2 supply heat.

Additionally, in FIG. 4, the energy is applied to the surface of the water or the gas Lg on the surface of the water before the temperature of the water reaches a temperature of the maximum ice crystal formation zone, more preferably, the phase

transition temperature due to the cooling. Thus, the water stably enters and maintains the supercooled state.

FIG. 5 is a schematic block diagram of a refrigerator employing a temperature control apparatus (or a non-freezing apparatus) of a storage room according to the present invention.

The refrigerator (or cooling apparatus) includes a main body apparatus 10, and the non-freezing apparatus 20 (or the temperature control apparatus of the storage room) mounted in the main body apparatus 10 (specifically, a storing unit, a storing space or a door provided in the main body apparatus 10) and cooled by the main body apparatus 10. The refrigerator may include a display device (not shown) installed on the storing unit door provided on the main body apparatus 10 and performing functions such as state display of the refrigerator and temperature setting.

The main body apparatus 10, which is composed of one or more storing units storing a stored object or a stored container and a bulkhead separating the plurality of storing units, includes a cooling means 11 cooling the storing unit, a sensing unit 12 sensing the temperature in the storing unit, the opening and closing of the storing unit door, etc., and a main control unit 13 receiving external commercial power (or another power) and controlling the cooling means 11 to maintain the temperature in the storing unit at a preset temperature (freezing temperature or refrigerating temperature). Here, like a general refrigerator or freezer, the storing unit includes the storing space storing the stored object and the storing unit door opening and closing the storing space such that a user can put the stored object into the storing unit and take the stored object out of the storing unit.

The cooling means 11 is divided into indirect-cooling type and direct-cooling type according to methods for cooling the storing space.

The indirect-cooling type cooling means includes a compressor compressing the refrigerant, an evaporator producing the cool air to cool a storing space or a stored object, a fan producing the forcible flow of the produced cool air, an inlet duct introducing the cool air into the storing space, and a discharge duct inducing the cool air passing through the storing space to the evaporator. In addition, the indirect-cooling type cooling cycle may include a condenser, a dryer, an expansion device, etc. The direct-cooling type cooling means includes a compressor compressing the refrigerant, and an evaporator installed in a case defining a storing space to be adjacent to an inner surface of the case and evaporating the refrigerant. Here, the direct-cooling type cooling cycle includes a condenser, an expansion valve, etc.

The sensing unit 12 may include a door sensing unit sensing the opening and closing of the storing unit door and may be formed of a kind of switch compressed by the closing of the storing unit door and restored by the opening thereof. Moreover, the sensing unit 12 may include a temperature sensing unit sensing the temperature in the storing unit. The main control unit 13 controls the cooling means 11 to perform the cooling operation according to the sensed temperature from the sensing unit 12, etc., and thus maintains a preset temperature in the storing unit. The main control unit 13 includes a memory (not shown) storing necessary data. Here, the preset temperature includes a refrigerating temperature (e.g., 1° C. to 6° C., etc.) for a refrigerating function, a freezing temperature (e.g., -10° C. to -20° C.), or a special freezing temperature (e.g., below -25° C.).

The main control unit 13 includes a power unit (not shown) receiving commercial power (e.g., 220 V, 100 V, 230 V, etc.) and rectifying, smoothing and transforming the commercial power into using power (e.g., 5 V, 12 V, etc.) necessary for the

main body apparatus 10 and the non-freezing apparatus 20. The power unit may be included in the main control unit 13 or provided in the main body apparatus 10 as a separate element. The main control unit 13 is connected to the non-freezing apparatus 20 by a power line PL to supply the necessary using power to the non-freezing apparatus 20. The main control unit 13 may be connected to the non-freezing apparatus 20 by a data line DL. The main control unit 13 may receive data (e.g., a current operation state of the non-freezing apparatus 20) from the non-freezing apparatus 20 through the data line DL. The data line DL may be selectively provided. Additionally, the main control unit 13 may transmit a control command to the non-freezing apparatus 20 through the data line DL to directly control the same.

The power line PL and the data line DL may be attached and detached to/from a connection portion 29 of the non-freezing apparatus 20 through a kind of socket-type connection portion 14.

The main body apparatus 10 may include an input unit (not shown) receiving the input of a setting command from the user, and a display unit (not shown) displaying the temperature of the storing unit, etc.

The input unit, which receives the input of temperature setting of the storing unit, an operation command of the non-freezing apparatus 20, function setting of a dispenser, and so on from the user, may be provided as, e.g., push buttons, a keyboard or a touch pad. For example, the operation command of the non-freezing apparatus 20 may be a rapid cooling command, a supercooling command, a slush command, etc.

The display unit may display an operation basically performed by the refrigerator, e.g. the temperature of the storing unit, the cooling temperature, the operation state of the non-freezing apparatus 20, etc. The display unit may be implemented as an LCD display or an LED display.

The main control unit 13 may control the temperature in the storing unit according to the temperature setting from the input unit or the prestored temperature setting and maintain the temperature in the storing unit at a temperature below at least the maximum ice crystal formation zone so that the control operation such as the supercooling control and the cooling control of the non-freezing apparatus 20 can be independently performed.

The non-freezing apparatus 20 includes a storage room with a storing space therein to store a container containing a liquid to be supercooled, the storage room being mounted and cooled in the storing unit.

The non-freezing apparatus 20 includes an input unit 21 receiving the input from the user, a display unit 22 displaying a state of the storing space or the stored object or an operation state of the non-freezing apparatus 20, a temperature sensing unit 23 sensing the temperature of the storing space or the stored object, a heat source supply unit 24 supplying heat to the storing space or generating heat in the storing space, a fan driving unit 25 operating a fan to circulate the air in the storing space by a forcible convection, an opening/closing means 26 introducing the cool air or the air from the storing unit to the storing space, a sensing unit 27 sensing the opening and closing of a storing space door opening and closing the storing space of the storage room, and a sub-control unit 28 controlling the heat source supply unit 24 which is a temperature control means based on the sensed temperature from the temperature sensing unit 23 so that the stored object in the storage room can be stored in a state at least desired by the user. The storage room includes a boundary portion separating upper and lower portions of a container to prevent or limit the air or heat exchange therebetween. The boundary portion

is located between an upper space and a lower space in the storing space and has a hole through which at least a portion of the container can pass.

The non-freezing apparatus 20 is operated by using power applied from the main control unit 13. A wiring for power supply (a wiring connected to the power line PL) is connected to the connection portion 14 of the main control unit 13 through the connection portion 29 and supplied with power.

The input unit 21, which enables the user to select an on/off switch function of the non-freezing apparatus 20 and a supercooling control command, a supercooling release command or a slush keeping command, may be provided as, e.g., push buttons, a keyboard or a touch pad.

The display unit 22, which displays an on/off state of the non-freezing apparatus 20 and a control (e.g., supercooling control, etc.) currently performed by the non-freezing apparatus 20, may be provided as an LCD display, an LED display, or the like. The display unit 22 may further include not only a visual display means but also an aural means (e.g., a speaker, etc.).

Moreover, the temperature sensing unit 23, which senses the temperature of the storing space or the temperature of the stored object, corresponds to a sensor formed on a sidewall of the storing space to sense the temperature of the air in the storing space or provided in proximity or contact with the stored object to accurately sense the temperature of the stored object. The temperature sensing unit 23 may apply a change value of a current value, a voltage value or a resistance value corresponding to the temperature to the sub-control unit 28. The temperature sensing unit 23 senses a sudden rise in the temperature of the stored object or the storing space during the phase transition of the stored object and enables the sub-control unit 28 to recognize the release of the supercooled state of the stored object.

In this embodiment, the temperature sensing unit 23 may be composed of an upper sensing unit (e.g., the one corresponding to the temperature sensor C1 of FIG. 3) formed in the upper side of the storage room which is the upper space of the storing space, and a lower sensing unit (e.g., the one corresponding to the temperature sensor C2 of FIG. 3) formed in the lower side of the storage room which is the lower space of the storing space.

The heat source supply unit 24 corresponds to a temperature control means controlling the temperature in the storing space to be changed to or maintained at a temperature corresponding to the supercooled state control, the slush keeping control, the supercooling release control, etc. The heat source supply unit 24 applies energy to the storing space. For example, the heat source supply unit 24 may produce thermal energy, electric or magnetic energy, ultrasonic energy, light energy, microwave energy, etc. and apply the energy to the storing space. In addition, the heat source supply unit 24 may be a thermoelectric element mounted on the upper and lower portions of the storing space, respectively, or attached to the boundary film.

Moreover, when the stored object is frozen, the heat source supply unit 24 may supply energy to thaw the stored object.

The heat source supply unit 24 is composed of a plurality of sub-heat source supply units and mounted on the upper or lower portion or the side surface of the storing space to supply energy to the storing space. In this embodiment, the heat source supply unit 24 includes an upper heat source supply unit (e.g., the one corresponding to the heat generation coil H1 of FIG. 3) formed in the upper space of the storage room which is the upper side of the storing space, and a lower heat source supply unit (e.g., the one corresponding to the heat generation coil H2 of FIG. 3) formed in the lower space of the

storage room which is the lower side of the storing space. The upper heat source supply unit and the lower heat source supply unit may be independently or integrally controlled by the sub-control unit 28.

The upper sensing unit and the lower sensing unit of the temperature sensing unit 23 are mounted on or adjacent to the surfaces with the upper heat source supply unit and the lower heat source supply unit thereon.

The fan driving unit 25 is an element driving the fan element Fr formed in the lower space of the storing space in the storage room. The driving of the fan element Fr makes the temperature distribution in the lower space of the storing space uniform. Due to the uniform temperature distribution, the stored object can be maintained in a stable state during the temperature maintenance, the temperature drop or the temperature rise.

The opening/closing means 26, which introduces the air or the cool air from the storing unit to the storing space, corresponds to, e.g., a damper. When the opening/closing means 26 is opened, more air or cool air can be introduced, which facilitates rapid cooling. On the contrary, when the opening/closing means 26 is closed, the inflow of the air from the storing unit to the storage room is minimized, which facilitates the temperature rise and the temperature maintenance.

The sensing unit 27 is a component sensing the opening and closing of the storing space door opening and closing the storing space of the storage room. Like the sensing unit 12, the sensing unit 27 may be a switch turned on/off by the opening and closing of the storing space door. In addition to the switch, the sub-control unit 28 may determine the opening and closing of the storing space door according to the sensed temperature from the temperature sensing unit 23. For example, if the storing space door is opened, a large temperature change such as a sudden rise in the temperature sensed by the temperature sensing unit 23 occurs due to the influence of the external temperature. Based on this temperature change, the sub-control unit 28 can determine that the storing space door has been opened. Afterwards, if the storing space door is closed, the sensed temperature will be slowly lowered. Based on this temperature drop, the sub-control unit 28 can determine that the storing space door has been closed. The sub-control unit 28 controls the heat source supply unit 24 according to the sensed temperature from the temperature sensing unit 23 to perform a necessary operation. Particularly, the sub-control unit 28 may control the upper heat source supply unit according to the sensed temperature from the upper temperature sensing unit and the lower heat source supply unit according to the sensed temperature from the lower temperature sensing unit, respectively.

As described above, the sub-control unit 28 may control the heat source supply unit 24 according to the sensed temperature from the temperature sensing unit 23, thereby independently performing the control with respect to the main control unit 13. For this independent control, the sub-control unit 28 may include a memory unit storing a control algorithm, etc.

The non-freezing apparatus 20 may further include a reception sensing unit checking that the container containing the liquid to be supercooled has been stored in the storing space. The reception sensing unit may be a weight sensor provided on a bottom surface of the storing space. As the bottom surface is lifted or lowered by the weight of the stored container, the sensor can sense such lifting and lowering. Additionally, the reception sensing unit may be composed of a light-emitting portion and a light-receiving portion formed on both sides of the storing space. When the light emitted by the light-emitting portion reaches the light-receiving portion,

11

it can be determined that the container has not been stored. When the emitted light does not reach the light-receiving portion, it can be determined that the container has been stored.

The reception sensing unit applies the sensing result to the sub-control unit 28, and the sub-control unit 28 cooperates with the sensing operation of the reception sensing unit. Particularly, the sub-control unit 28 can perform the supercooled state control only when the container has been stored.

In addition, when the input unit 21 acquires the reception input of the stored object from the user, the sub-control unit 28 can determine the reception of the stored object. That is, when the input unit 21 acquires a reception input command of the stored object or a withdrawal input command of the stored object, the sub-control unit 28 may perform the control according to this command.

FIG. 6 illustrates a first embodiment of a temperature graph and an operation state view of processes performed by the refrigerator including the non-freezing apparatus 20 according to the present invention. In this embodiment, the temperature in the storing unit of the refrigerator is maintained at, e.g.,  $-17^{\circ}\text{C}$ .

The non-freezing apparatus 20 performs different processes according to the current temperature of the storing space (upper space or lower space) and the maintenance temperature or the maintenance state of the stored object. Hereinafter, the processes which can be performed by the non-freezing apparatus 20 will be described.

First, it is assumed that the current temperature is over the phase transition temperature (or a preset temperature-control start temperature region). The preset temperature-control start temperature region may be set as, e.g.,  $0^{\circ}\text{C}$ . to  $3^{\circ}\text{C}$ . In the current temperature, a process of rapid cooling is performed. That is, the necessary control is to rapidly cool the upper and lower spaces of the storing space. The sub-control unit 28 maintains the heat source supply unit 24 (upper and lower) in the off state and the opening/closing means 26 in the on state (open state) such that the cool air of the storing unit can be rapidly introduced into the lower space, and controls the fan driving unit 25 to operate the fan element such that the introduced cool air can be circulated by a forcible convection, thereby rapidly lowering the temperature of the upper space and the lower space. In this process, preferably, the on state of the opening/closing means 26 and the on state of the fan driving unit 25 are maintained for at least a given time. In this embodiment, the process of rapid cooling corresponds to a time 0 to t1 section. In addition, a process of maintaining the preset temperature-control start temperature region can be performed following the process of rapid cooling. In the process of maintaining the preset temperature-control start temperature region, since the temperature of the storing unit is relatively low, the heat source supply unit 24 is operated to maintain the temperature of the storing space. Particularly, when the upper heat source supply unit and the lower heat source supply unit are operated together, the upper space and the lower space maintain this temperature region. In this maintaining process, the opening/closing means 26 is closed. Moreover, preferably, the fan driving unit 25 is maintained in the off state.

A process of entering a supercooling temperature region T1 may be performed continuously to the process of rapid cooling. The entering process may be discontinuously performed with respect to the process of rapid cooling. For example, the entering process may be performed after the process of maintaining the preset temperature-control start temperature region is performed for a given time or according to a supercooling maintenance command of the user.

12

In this entering process, since the temperature of the lower space starts to be lowered to a temperature below the phase transition temperature, the upper heat source supply unit is operated in the on state intermittently, discontinuously, or using low power such that the temperature of the upper space (i.e., the air over the stored object) can be maintained at a temperature (e.g.,  $5^{\circ}\text{C}$ .) higher than the phase transition temperature. Here, the lower heat source supply unit is maintained in the off state such that the temperature of the stored object can be lowered to a desired supercooling temperature region. Here, the opening/closing means 26 is switched to the on state (open state) such that the cool air of the storing unit can be rapidly introduced into the lower space, and the fan element is switched to the on state by the fan driving unit 25 such that the introduced cool air can be circulated by a forcible convection, thereby rapidly lowering the temperature of the upper space and the lower space. This entering process is performed in a time t1~t2 section to enter the supercooling temperature region T1 below the phase transition temperature.

When the temperature of the lower space reaches the supercooling temperature region T1 (e.g.,  $-7^{\circ}\text{C}$ . to  $-8^{\circ}\text{C}$ .), a process of maintaining the supercooling temperature region T1 is performed continuously to the entering process. For the maintaining process, the upper heat source supply unit is repeatedly turned on/off or uses given power to maintain the temperature, and the lower heat source supply unit is repeatedly turned on/off or uses given power to maintain the temperature of the lower space in the supercooling temperature region T1. Here, the sub-control unit 28 controls the on/off of the opening/closing means 26 and the fan driving unit 25 according to the temperature of the lower space such that the temperature of the lower space can be maintained in the supercooling temperature region T1. The stored object stored in the storing space can be maintained in the supercooled state, i.e., the non-frozen state by the process of maintaining the supercooling temperature region T1. This maintaining process can be performed for a time desired by the user or a preset time. In this embodiment, for the convenience of the explanation, the maintaining process is performed in a time t2~t3 section.

A process of lowering the temperature may be performed continuously or independently with respect to the process of maintaining the supercooling temperature region T1 or according to the user's command (e.g., a slush producing command or a slush keeping command). In a time t3, the sub-control unit 28 controls the heat source supply unit 24 in the off state and the opening/closing means 26 and the fan driving unit 25 in the on state to rapidly lower the temperature of the storing space. As a result, it makes the temperature of the stored object rapidly lowered. In a time t4, the supercooled state of the stored object is released and the temperature of the stored object is suddenly raised due to the temperature drop such that the phase transition may occur. Alternatively, the process of lowering the temperature may be performed after the supercooling is released by a supercooling release operation of a separate means (e.g., electric shock, vibration shock, etc.) which can release the supercooled state of the stored object (i.e., after the crystallization occurs). The release of the supercooling may be determined based on the phenomenon that the temperature of the storing space is raised due to the temperature rise of the stored object.

The process of lowering the temperature is performed until the temperature of the lower space reaches and maintains, e.g., a temperature T2 (a cooling temperature of the storing unit). In this embodiment, this process is performed in a time t3~t6 section. That is, when the temperature of the lower

13

space reaches the temperature T2 in a time t5, the temperature is not lowered but maintained (the process of maintaining the temperature). More slush can be produced in the stored object during the phase transition by the processes of lowering and maintaining the temperature. As the time for performing the process of lowering the temperature, particularly, the time for performing the process of maintaining the temperature is associated with an amount of slush to be produced, this process may be performed for a preset time or a time decided by a separate input (an input time or a slush amount) of the user.

After the processes of lowering and maintaining the temperature, a process of raising the temperature is performed in a time t6. The sub-control unit 28 switches the fan driving unit 25 and the opening/closing means 26 into the off state and controls the heat source supply unit 24 (upper heat source supply unit and lower heat source supply unit) in the on state. Accordingly, the temperature of the lower space (and the upper space) is raised. The process of raising the temperature maintains the temperature of the lower space at a slush keeping temperature T3 after a time t7 when the temperature of the lower space reaches the slush keeping temperature T3. In the early stage of the process of raising the temperature, the heat source supply unit 24 is on for a relatively-long time or uses high power to rapidly raise the temperature. Afterwards, the heat source supply unit 24 is intermittently on/off or uses low power to maintain the temperature. Moreover, after the early stage, the fan driving unit 25 is also intermittently on/off such that the temperature distribution of the lower space can be uniform. The crystallization size is decided according to the degree of the slush keeping temperature T3. That is, if the slush keeping temperature T3 is low, the crystal size of the slush produced is relatively large, and if the slush keeping temperature T3 is high, the crystal size of the slush produced is relatively small. The slush keeping temperature T3 may be maintained at a temperature below the phase transition temperature to prevent the slush from being changed to liquid.

As described above, the upper heat source supply unit is on/off-controlled so that the temperature of the upper space can exceed the temperature-control start temperature region expect the temperature drop section. However, in the process of keeping the slush, the upper heat source supply unit may be on/off-operated to maintain the temperature of the upper space at the slush keeping temperature T3.

The embodiment of FIG. 6 may be a case where the temperature control apparatus (or the non-freezing apparatus) is initially installed in the storing unit performing the cooling. In another case, the temperature control apparatus has been installed in the storing unit of the refrigerator performing the cooling, but has not been operated without receiving the input of an operation command, etc. Here, the temperature of the storing space in the temperature control apparatus is substantially identical to the temperature of the storing unit. The temperature control apparatus can start the temperature control when the user puts the stored object into the storing space or inputs the operation command. In this situation, as the temperature of the storing space is significantly low, the phase transition of the stored object may occur during the cooling. Therefore, the heat source supply unit 24 (upper heat source supply unit and lower heat source supply unit) is controlled to operate in the early stage so that the temperature of the storing space can enter the supercooling temperature region. In this entering process, both the fan driving unit 25 and the opening/closing means 26 are maintained in the off state or only the opening/closing means 26 is maintained in the off state such that the temperature of the upper space of the storing space exceeds the temperature-control start temperature region and the temperature of the lower space enters the supercooling

14

temperature region. After the temperature of the lower space enters the supercooling temperature region, the heat source supply unit 24, the fan driving unit 25 and the opening/closing means 26 are controlled as in the processes succeeding the process of maintaining the supercooling temperature region of FIG. 6.

During the cooling processes, while the stored object is maintained in the supercooled state or cooled to a temperature below the phase transition temperature, the freezing or crystallization can be sensed and determined. The sub-control unit 28 and the sensing unit 27 can determine the release of the supercooled state by sensing the temperature change that the temperature of the stored object is suddenly raised from, e.g.,  $-4^{\circ}\text{C}$ . When the supercooled state is released, the heat source supply unit 24 (upper heat source supply unit and lower heat source supply unit) is operated to perform the thawing. Upon the completion of the thawing, the cooling is restarted. Preferably, the opening/closing means 26 is closed during the thawing process. The fan driving unit 25 may be intermittently on/off-controlled to achieve the uniform temperature.

The sub-control unit 28 may intercept the power supply to the respective elements according to the on/off switch input of the non-freezing apparatus from the input unit 21, thereby preventing their operation.

The input unit 21 further has a function of acquiring a thawing command. The sub-control unit 28 operates the heat source supply unit 24 to apply energy (particularly, heat energy) to thaw the stored object according to the thawing command from the input unit 21.

FIG. 7 is a flowchart showing a first determination and display method in the refrigerator according to the present invention. The method of FIG. 7 may be performed in the whole process of FIG. 6. Preferably, the first determination and display method is performed after power is applied to the non-freezing apparatus 20 or a supercooling operation command is acquired through the input unit 21.

At step S11, the non-freezing apparatus 20 is cooled in the storing unit.

At step S13, the sub-control unit 28 senses the temperature of the storing space (specifically, the lower space) through the temperature sensing unit 23 and determines whether the sensed temperature has entered the supercooling temperature region. If the sensed temperature has entered the supercooling temperature region, the sub-control unit 28 goes to step S15, and if not, the sub-control unit 28 stands ready.

At step S15, the sub-control unit 28 calculates the accumulated time during which the sensed temperature entering the supercooling temperature region is maintained in the supercooling temperature region. Here, the sub-control unit 28 accumulates only the time during which the sensed temperature is maintained in the supercooling temperature region and excludes the time during which the sensed temperature goes out of the supercooling temperature region.

At step S17, the sub-control unit 28 compares the accumulated time with a supercooled-state determination time. The supercooled-state determination time corresponds to the time by which the sub-control unit 28 can determine that the stored object is maintained in the supercooled state or has been stably maintained in the supercooled state. The supercooled-state determination time may be differently set and stored according to the kind, amount, volume or the like of the stored object. The sub-control unit 28 can store the determination time set based on the volume of the storing space and determine whether the stored object has a supercooled state in the maximum storable volume. For example, the supercooled-state determination time may be set to be 7 hours. If the

15

accumulated time is equal to or greater than the supercooled-state determination time, the sub-control unit 28 goes to step S21, and if not, the sub-control unit 28 goes to step S19.

At step S19, the sub-control unit 28 determines and displays the proceeding degree of the supercooled state according to a ratio of the accumulated time to the supercooled-state determination time or a proximity degree of the accumulated time to the supercooled-state determination time. Thereafter, the sub-control unit 28 goes to step S15. For example, if the accumulated time is 4 hours and the supercooled-state determination time is 8 hours, the proceeding degree is determined to be 50%. Alternatively, the proceeding degree may be displayed using a number, figure, graph or the like corresponding to the ratio or the proximity degree (%) (the accumulated time/the supercooled-state determination time $\times$ 100). In this step, the sub-control unit 28 may determine the current state of the stored object as a cooled state different from the supercooled state.

At step S21, the sub-control unit 28 determines that the stored object, which is being currently cooled, has the supercooled state according to the accumulated time, and displays the supercooled state through the display unit 22. The visual or aural display can be performed.

The above steps S15 to S19 may be repeatedly performed until the stored object or the storing space is determined as having the supercooled state. Finally, when the stored object or the storing space has the supercooled state, the routine is ended.

FIG. 8 is a flowchart showing a second determination and display method in the refrigerator according to the present invention. The method of FIG. 8 may be performed in the whole process of FIG. 6. Preferably, the second determination and display method is performed after power is applied to the non-freezing apparatus 20 or a supercooling operation command is acquired through the input unit 21.

At step S31, the non-freezing apparatus 20 is cooled in the storing unit.

At step S33, the sub-control unit 28 senses the temperature of the storing space (specifically, the lower space) through the temperature sensing unit 23 and determines whether the sensed temperature has entered the supercooling temperature region. If the sensed temperature has entered the supercooling temperature region, the sub-control unit 28 goes to step S35, and if not, the sub-control unit 28 stands ready.

At step S35, the sub-control unit 28 determines whether a given time has elapsed using a built-in timer. The given time corresponds to the minimum reference time for determining the supercooled state, e.g., 5 hours.

At step S37, the sub-control unit 28 calculates the average temperature from when the sensed temperature enters the supercooling temperature region.

At step S39, the sub-control unit 28 determines whether the calculated average temperature is included in the supercooling temperature region. If the average temperature is included in the supercooling temperature region, the sub-control unit 28 goes to step S43, and if not, the sub-control unit 28 goes to step S41.

At step S41, the sub-control unit 28 calculates a ratio of the average temperature to the supercooling temperature region or a proximity degree of the average temperature to the supercooling temperature region and determines the proceeding degree of the supercooled state of the stored object. In addition, the sub-control unit 28 enables the display of the determined proceeding degree. For example, if the highest temperature of the supercooling temperature region is  $-4^{\circ}\text{C}$ . and the average temperature is  $-3.5^{\circ}\text{C}$ ., the proceeding degree is determined to be 87.5%. The sub-control unit 28 goes back to

16

step S37 to calculate the average temperature again. In this step, the sub-control unit 28 may determine the current state of the stored object as a cooled state different from the supercooled state.

At step S43, the sub-control unit 28 determines that the stored object, which is being currently cooled, has the supercooled state according to the average temperature, and displays the supercooled state through the display unit 22. The visual or aural display can be performed.

The above steps S37 to S41 may be repeatedly performed to continuously calculate the average temperature until the average temperature is included in the supercooling temperature region.

FIGS. 9 to 12 are views of examples of the display method.

As illustrated in FIG. 9, a display unit 22a may be composed of a display light L1 indicating the supercooled state and a display light L2 indicating the non-supercooled state. If either the display light L1 or the display light L2 is on, it indicates that the non-freezing apparatus 20 is in operation. The display light L1 or L2 may be formed of a LED, etc.

As illustrated in FIG. 10, a display unit 22b includes a means L3 which can display multiple stages. As shown, the means L3 can display the proceeding degree by four stages. The means L3 may be formed of a LED or LCD, etc.

As illustrated in FIG. 11, a display unit 22c includes a means L4 displaying the proceeding degree using a number. Since the means L4 displays the proceeding degree using the number, it can display the proceeding degree by multiple stages. The means L4 may be formed of a LED or LCD, etc.

As illustrated in FIG. 12, a display unit 22d includes a means L5 displaying the proceeding degree using a character. The means L5 can display the proceeding degree as, e.g., 'Proceeding' or 'Cooled state' and display the supercooled state as 'Completed' or 'Supercooled state'. The means L5 may be formed of a LED or LCD, etc.

FIG. 13 is a view of a refrigerator according to a first embodiment of the present invention. The refrigerator 1000 is an apparatus supplying the cool air into a cooling space 1300 and 1400 using a cooling cycle. FIG. 13 illustrates a state where a non-freezing apparatus 2000 is installed in a freezing chamber 1300 of a side-by-side refrigerator which is an example of the refrigerator 1000. The cooling space 1300 and 1400 in the refrigerator 1000 is divided into the freezing chamber 1300 and a refrigerating chamber 1400 by a bulkhead 1500. Support portions (not shown) are formed on both sides surfaces of the freezing chamber 1300 to protrude therefrom, and hook-shaped ribs 2200 supported by the support portions (not shown) and fixing the non-freezing apparatus 2000 are formed on both side surfaces of the non-freezing apparatus 2000. The non-freezing apparatus 2000 is fixed in the freezing chamber 1300 by the hook-shaped ribs 2200 and the support portions (not shown) and may be detachable from the freezing chamber 1300 like other general shelves. The non-freezing apparatus 2000 needs power supply. Preferably, power connectors (not shown) are provided between the refrigerator 1000 and the non-freezing apparatus 2000 and connected to each other to supply power. The power connectors (not shown) may be contact-type connectors such as battery chargers formed in the corresponding positions of the refrigerator 1000 and the non-freezing apparatus 2000 and transferring power through the contact, or a pair of female and male port-type connectors engaged with ends of power transfer cables provided in the refrigerator 1000 and the non-freezing apparatus 2000, respectively. Additionally, the non-freezing apparatus 2000 may be fixed to the freezing chamber 1300 using screws or the like not to be detached therefrom. In this situation, not a separate power connector (not shown) but



17

a general electric wire is provided between the non-freezing apparatus **2000** and the freezing chamber **1300** to supply power from the refrigerator **1000** to the non-freezing apparatus **2000**. Meanwhile, when it is intended to display a working state, a supercooling proceeding state and so on of the non-freezing apparatus **2000** through an external display (not shown) installed on the outside of the refrigerator **1000**, it is preferable to form the power connector (not shown) or the electric wire to transmit electricity in two ways so as to transfer information from a PCB (not shown) which is a control unit controlling the operation of the non-freezing apparatus **2000** to the external display (not shown) or a control unit (not shown) of the refrigerator **1000**.

FIG. **14** is a view of a door provided in a refrigerator according to a second embodiment of the present invention. In the refrigerator according to the second embodiment of the present invention, a non-freezing apparatus **2000** is installed in a freezing chamber door **1100** of the refrigerator. The freezing chamber door **1100** serves to open and close a freezing chamber **1300**. The non-freezing apparatus **2000**, an ice bank **1600** and an ice maker **1700** are installed in the freezing chamber door **1100** sequentially from the lower side. The ice maker **1700** is supplied with water to make ice. When the ice maker **1700** finishes the ice making, the ice made in the ice maker **1700** is automatically or manually supplied to the ice bank **1600**. In a case where the ice is automatically supplied from the ice maker **1700** to the ice bank **1600**, an ice tray (not shown) in which the ice is made is rotatably installed in the ice maker **1700** and rotated to drop the ice to the lower side upon the completion of the ice making. The ice bank **1600** includes an outer casing **1610** mounted in the freezing chamber door **1100** and a drawer **1620** which can be pulled out from the outer casing **1610**. The outer casing **1610** has an opening portion on the upper side so that the ice dropped from the ice maker **1700** can be introduced therethrough. The ice made in the ice maker **1700** is dropped to the lower portion by the rotation of the ice tray (not shown), passed through the opening portion formed in the outer casing **1610** of the ice bank **1600**, and stored in the drawer **1620** of the ice bank **1600**. When dropped to the ice bank **1600**, the ice gives a shock to the ice bank **1600**. This shock may be transferred to the freezing chamber door **1100**, the non-freezing apparatus **2000**, etc. Accordingly, the non-freezing apparatus **2000** has a groove **2100** having a larger section than that of the drawer **1620**. As such, when the ice is dropped to the drawer **1620**, the drawer **1620** can be downwardly moved to reduce the shock.

FIGS. **15** and **16** are exploded perspective views of a non-freezing apparatus according to an embodiment of the present invention.

The non-freezing apparatus **2000** according to the embodiment of the present invention includes a casing **100** defining the inner space for storing a container and a door **200** opening and closing the casing **100**, and is installed in a refrigerator **1000** storing food at a temperature below  $0^{\circ}\text{C}$ . such as a freezing chamber of the refrigerator **1000**. The casing **100**, which separates the outer space, i.e., the space of the refrigerator **1000** in which the non-freezing apparatus **2000** is installed from the inner space of the non-freezing apparatus **2000**, includes outer casings **110** and **120** forming the external appearance of the non-freezing apparatus **2000**. The outer casings **110** and **120** include a front outer casing **110** and a rear outer casing **120**. The front outer casing **110** forms the external appearance of the front and lower portions of the non-freezing apparatus **2000**, and the rear outer casing **120** forms the external appearance of the rear and upper portions of the non-freezing apparatus **2000**. The casing **100** enables upper and lower portions of container containing a liquid to

18

be located and stored in different temperature regions. More specifically, the lower portion of the container is located in a temperature region (about  $-1^{\circ}\text{C}$ . to  $-5^{\circ}\text{C}$ .) of the maximum ice crystal formation zone, and the upper portion of the container is located in a higher temperature region (about  $-1^{\circ}\text{C}$ . to  $2^{\circ}\text{C}$ .) in which the ice crystals are not easily formed. For this purpose, the casing **100** includes a lower space **100L** having the temperature region (about  $-1^{\circ}\text{C}$ . to  $-5^{\circ}\text{C}$ .) of the maximum ice crystal formation zone, and an upper space **1000** having the temperature region (about  $-1^{\circ}\text{C}$ . to  $2^{\circ}\text{C}$ .) in which the ice crystals are not easily formed. The upper space **1000** and the lower space **100L** are separated by a bulkhead **140**. The casing **100** includes a lower casing **130** defining the lower space **100L** with the bulkhead **140** and an upper casing **150** defining the upper space **1000** with the bulkhead **140**.

A flow fan **170** is installed at the rear of the lower space **100L** so that the liquid stored in the lower portion of the container located in the lower space **100L** can rapidly reach the temperature region (about  $-1^{\circ}\text{C}$ . to  $-5^{\circ}\text{C}$ .) of the maximum ice crystal formation zone and have a supercooled state. In addition, a lower heater (not shown) is provided to adjust the temperature of the lower space **100L**. An upper heater (not shown) is installed adjacent to the upper casing **150** so that the upper portion of the container located in the upper space **1000** can be maintained in the temperature region (about  $-1^{\circ}\text{C}$ . to  $2^{\circ}\text{C}$ .) in which the ice crystals are not easily formed. Moreover, a separation film **142** made of an elastic material is installed on the bulkhead **140** to prevent the heat exchange from occurring between the upper space **1000** and the lower space **100L** having different temperatures due to a forcible flow produced by the flow fan **170**. Further, preferably, fixing plates **144**, which can be fixed to the bulkhead **140** by screws or the like, are provided to press the separation film **142** in the up-down direction to fix the separation film **142** to the bulkhead **140**.

Meanwhile, an insulation material **112** for insulating the lower space **100L** from the outer space is provided at the lower portions of the outer casings **110** and **120**, and an insulation material **122** for insulating the upper space **1000** from the outer space is provided at the upper portions of the outer casings **110** and **120**. In addition, a power switch **182**, a display unit **184** and the like are installed between the front outer casing **110** and the insulation material **122**, and the PCB (not shown) controlling electronic components, such as the power switch **182**, the display unit **184**, the upper and lower heaters (not shown), the flow fan **170** and a damper **190**, and a PCB installation portion **186** are installed between the rear outer casing **120** and the insulation material **122**. The rear outer casing **120** further includes an opening portion **124** through which the PCB installation portion **186** can be detached in an assembled state of the outer casings **110** and **120** for the PCB installation, and a PCB cover **124c** covering the opening portion **124** after the mounting of the PCB installation portion **186**.

In the meantime, a bulkhead is formed to prevent the cool air from flowing from the lower portion of the rear space **100R** to the upper portion thereof and reducing the temperature of the upper space **1000**. A rib **120r** formed on the rear outer casing **120** and a rib **140r** formed on the bulkhead **140** of the upper portion of the lower casing **130** to protrude from the lower casing **130** backwards overlap with each other, thereby forming the bulkhead. Preferably, a rib **150r** having a shape corresponding to that of the bulkhead **140** of the upper portion of the lower casing **130** is provided at the lower portion of the upper casing **150** to protrude therefrom backwards. The rib **120r** formed on the rear outer casing **120**, the rib **140r** formed

19

on the bulkhead **140** and the rib **150r** formed on the upper casing **150** overlap with each other, thus forming the bulkhead of the rear space **100R**.

The door **200** is installed on the front surface of the front outer casing **110** to open and close the lower space **100L**. The door **200** includes a door panel **220** made of a transparent or semitransparent material in a door casing **210**, a door frame **230** fixed to the door casing **210** and fixing the door panel **220** therewith, and a gasket **240** mounted at the rear of the door frame **230** and sealing up between the door **200** and the front outer casing **110**. The non-freezing apparatus **2000** according to the embodiment of the present invention includes a plurality of door panels **220**. The respective door panels **220** are installed between the door casing **210** and the door frame **230** with a gap such that air layers are formed between the door panels **220**. The air layers not only compensate for a low-insulation property of the door **200** but also prevent the frosting of the door **200**, i.e., the door panels **220**. The gasket **240** is made of an elastic material to seal up the gap between the door **100** and the front outer casing **110**, thereby preventing the heat exchange from occurring between the cooling space **1300** and **1400** in which the non-freezing apparatus **2000** is mounted and the inside of the non-freezing apparatus **2000**. That is, the gasket **240** can prevent leakage of the cool or hot air. Meanwhile, a rear space R is defined by the rear outer casing **120**, the lower casing **130** and the upper casing **150**. The flow fan **170**, the damper **190** and the lower heater (not shown) are installed in the rear space R. Particularly, the PCB installation portion **186** is installed at the upper portion of the rear space R to be detachable therefrom. The lower heater (not shown), the upper heater (not shown), the lower sensor (not shown), the upper sensor (not shown), the flow fan **170**, the damper **190**, the power switch **182** and the display unit **184** are connected to the PCB through an electric wire. The PCB is fixed in the PCB installation portion **186**, and then the PCB installation portion **186** is fitted into a groove formed in the insulation material **122** of the upper space through the opening portion **124** formed in the rear outer casing **120**. The electric wire connecting the PCB to the respective electronic components is connected to the PCB with a sufficient length to pull out the PCB installation portion **186** through the opening portion **124** of the rear outer casing **120**. Accordingly, when the PCB is to be repaired or replaced, it is not necessary to separate the front outer casing **110** from the rear outer casing **120**, which improves the convenience of maintenance and repair. In addition, grooves **136** and **156** are provided in the upper portion of the lower casing **130** and the lower portion of the upper casing **150**, respectively, so that the electric wire connecting the PCB to the respective electronic components can be fitted thereinto. The upper portion of the lower casing **130** and the lower portion of the upper casing **150** are fixed to each other in an overlapping manner. The separation film **142** or the fixing plate **144** described above are located between the upper portion of the lower casing **130** and the lower portion of the upper casing **150**. Moreover, when the PCB installation portion **186** is inserted into the insulation material **122** of the upper space in the rear outer casing **120**, the opening portion **124** is closed by the PCB cover **124c**. If the cool air of the cooling space infiltrates through the opening portion **124** during the operation, there is the possibility of lowering the temperature of the upper space **1000** which should be maintained at a higher temperature than that of the lower space **100L**, in addition to the cooling space. Therefore, there is a disadvantage in that a heating value of the upper heater (not shown) should be increased. When the opening portion **124** is closed by the PCB cover **124c**, the energy

20

efficiency can be improved and the liquid can be stably changed to the supercooled state.

FIG. **17** is a view of the rear space of the non-freezing apparatus according to the embodiment of the present invention, and FIG. **18** is a perspective view of the non-freezing apparatus according to the embodiment of the present invention. As described above, the damper **190** is installed at the lower portion of the rear space **100R** to control the inflow of the cool air. In addition, the flow fan **170** installed on the rear surface of the lower casing **130** produces a forcible flow such that the air introduced into the rear space **100R** can be introduced into the lower space **100L** and the air of the lower space **100L** can be discharged again to the rear space **100R**. A discharge grill **172** is provided in the installation position of the flow fan **170** in the lower casing **130** so that the flow produced by the flow fan **170** can flow therethrough, thereby forming a passage from the rear space **100R** to the lower space **100L**. Moreover, first discharge holes **310a**, **310b**, **310c** and **310d** are formed in the rear surface of the lower casing **130** to discharge the flow from the lower space **100L** to the rear space **100R**. The first discharge holes **310** are formed at both side ends. Four first discharge holes **310a**, **310b**, **310c** and **310d** are formed in twos in the up-down direction. The flow produced by the flow fan **170** is introduced into the lower space **100L** through the discharge grill **172**, and then discharged again through the first discharge holes **310a**, **310b**, **310c** and **310d** located at both side ends. Thus, a natural cooling passage is formed in the lower space **100L**. In the meantime, second discharge holes **320** are formed in the lower portion of the lower space **100L** to discharge the flow discharged through the first discharge holes **310a**, **310b**, **310c** and **310d** to the cooling space. Here, bulkheads **330a** and **330b** are installed between the flow fan **170** and the first discharge holes **310a**, **310b**, **310c** and **310d** to prevent the flow discharged through the first discharge holes **310a**, **310b**, **310c** and **310d** from flowing to the central portion in which the flow fan **170** is located and flowing into the lower space **100L** again.

Further, some of the flow flowing into the lower space **100L** through the first discharge holes **310a**, **310b**, **310c** and **310d** and cooling the liquid stored in the container is discharged directly to the cooling space through third discharge holes **340** located in the lower portion of the lower space **100L**. Preferably, the third discharge holes **340** are formed in the left and right in the same number to form symmetric passages. Accordingly, when the damper **190** is opened and the flow fan **170** is operated, the cool air is introduced from the cooling space to the rear space **100R** through the damper **190**, and then introduced from the rear space **100R** to the lower space **100L** through the discharge grill **172**, thus cooling the lower portion of the container containing the liquid in the non-freezing apparatus **2000**.

Some of the flow exchanging heat with the liquid contained in the container and cooling the liquid is discharged directly to the cooling space through the third discharge holes **340** located at both sides of the lower portion of the lower space **100L**. The rest of the flow is discharged to the rear space **100R** through the first discharge holes **310a**, **310b**, **310c** and **310d** of both side ends, and then discharged to the outside (cooling space) through the second discharge holes **320a** and **320b**.

Meanwhile, fourth discharge holes **350a** and **350b** are further formed in the lower casing **130** to be located inside the bulkheads **330a** and **330b**. That is, the bulkheads **330a** and **330b** exist between the fourth discharge holes **350a** and **350b**, and the first discharge holes **310a**, **310b**, **310c** and **310d** and the second discharge holes **320a** and **320b**. In a state where the damper **190** is closed, when the flow fan **170** is operated,

21

the flow discharged from the rear space **100R** to the lower space **100L** through the discharge grill **172** is circulated in the lower space **100L** and discharged again to the rear space **100R** through the fourth discharge holes **350a** and **350b**. That is, when it is determined that the temperature of the lower space **100L** reaches an appropriate temperature for storing the liquid in the supercooled state, in a state where the damper **190** is closed, the flow is circulated between the lower space **100L** and the rear space **100R** through the discharge grill **172** and the fourth discharge holes **350a** and **350b**, and the cool air is not introduced any more from the external cooling space. Referring to FIG. **18**, a trough **116** is formed at a contact portion of the door **200** and the front outer casing **110**. The trough **116** prevents dews or moisture deposited on the container from being frozen on the door **200** or the front outer casing **110**. Without the trough **116**, the door **200** and the front outer casing **110** are not closely attached to each other but have a gap therebetween, and the cool air infiltrates into the gap and lowers the temperature of the lower space **100L**. That is, since the dews deposited on the door **200** or the front outer casing **110** are dropped and collected in the trough **116**, the frosting or freezing of the moisture does not occur on the bottom surface of the front outer casing **110** brought into contact with the door **200**.

FIG. **19** is a view of the rear of the non-freezing apparatus according to the embodiment of the present invention. Fifth discharge holes **360a**, **360b** and **360c** are formed in a center of the rear surface of the rear outer casing **120** to discharge the flow from the rear space **100R** to the cooling space. Some of the cool air introduced from the cooling space to the rear space **100R** through the damper **190** is not introduced into the lower space **100L** through the discharge grill **172** but discharged again to the cooling space through the fifth discharge holes **360a**, **360b** and **360c**.

In the meantime, a plurality of ribs **125** are formed on the rear surface of the rear outer casing **120**. The ribs **125** serve to leave a spacing between the rear surface of the rear outer casing **120** and the installation surface. When the non-freezing apparatus **2000** is installed in the refrigerator **1000** like the embodiment of the present invention, the ribs **125** maintain a spacing between the inner surface of the refrigerator **1000** and the rear surface of the rear outer casing **120**. The inner surface of the refrigerator **1000** includes the inner surfaces of the freezing chamber door **1100** and the refrigerating chamber door **1200**. In addition, a separate rib **126** is provided to enclose the fifth discharge holes **360a**, **360b** and **360c** formed in the center of the rear surface of the rear outer casing **120** so that the flow discharged through the fifth discharge holes **360a**, **360b** and **360c** of the rear outer casing **120** can be guided to the lower portion of the rear outer casing **120**. The separate rib **126** encloses the fifth discharge holes **360a**, **360b** and **360c** in three sides except the lower side such that the flow

22

discharged through the fifth discharge holes **360a**, **360b** and **360c** is naturally guided to the lower side of the non-freezing apparatus **2000**.

The present invention has been described in connection with the exemplary embodiments and the accompanying drawings. However, the scope of the present invention is not limited thereto but is defined by the appended claims.

The invention claimed is:

1. A refrigerator, comprising:

a storing space, the storing space having an upper space, a lower space and a separation film located between the upper space and the lower space, the separation film separating upper and lower portions of a container having a stored liquid to prevent or limit the air or heat exchange therebetween, the separation film including a hole through which at least a portion of the container can pass;

a cooling circuit having a compressor and an evaporator;

a control apparatus, the control apparatus controlling the cooling circuit to cool the lower space to a temperature below a maximum ice crystal formation zone of the stored liquid;

a temperature sensing unit sensing temperature of the storing space;

a determination unit calculating an accumulated time during which the temperature of the storing space is maintained in a supercooling temperature range below the maximum ice crystal formation zone of the stored liquid after the sensed temperature enters the supercooling temperature range, comparing the accumulated time with a supercooled-state determination time and determining that the stored liquid is in the supercooled state if the accumulated time is equal to or greater than the supercooled-state determination time; and

a display visually displaying the supercooled state determined by the determination unit.

2. The refrigerator of claim 1, wherein the determination unit enables the display to display stages corresponding to a percent of the accumulated time to the supercooled-state determination time.

3. The refrigerator of claim 1, wherein the determination unit performs the calculating after a supercooling operation command is acquired from an input unit connected to the control apparatus.

4. The refrigerator of claim 1, wherein the temperature sensing unit senses the temperature of the lower space and the determination unit calculates the accumulated time during which the temperature of the lower space is maintained in the supercooling temperature range after the sensed temperature enters the supercooling temperature range.

5. The refrigerator of claim 1, wherein the supercooled-state determination time is differently set and stored according to the kind, amount, and volume of the stored liquid.

\* \* \* \* \*